TEMPORAL TRENDS IN DRYLAND SOIL CARBON FLUXES IN RESPONSE TO ARTIFICIAL AND NATURAL PULSED MOISTURE EVENTS

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Dedication

Without my mom, this thesis would not have been possible. Her unwavering support, encouragement, and love have been the foundation that has allowed me to pursue my dreams. Throughout my academic journey, she has been my constant cheerleader, my sounding board, and my guiding light. Her sacrifices, both big and small, have made it possible for me to reach this milestone. I dedicate this thesis to my mom, who has always believed in me even when I doubted myself. Thank you, mom, for everything you have done for me. I love you.

Briana

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Abstract

Critical zone processes in drylands play a crucial role in the global carbon cycle, and one of the most important processes is soil CO_2 efflux at the interface between soils and the atmosphere, which represents a main pathway for loss of carbon. Predicting the carbon dynamics at this interface is challenging due to the complexity of belowground processes, which include both biotic (soil respiration) and abiotic (calcite precipitation) production of CO_2, as well as transport processes that include both diffusive and advective components. In this study, we aimed to investigate the contribution of soil air displacement to soil CO_2 efflux during pulsed moisture events (natural rainfall, artificial rainfall, and irrigation) in a shrubland and agricultural site. To achieve this, we took simultaneous measurements of both diffusion using soil CO_2 concentrations (Fick's Law calculations) and total CO_2 efflux at the surface (eosFD sensors) and compared the two. Our results demonstrate that the introduction of water to the soil during pulsed moisture events immediately increases CO_2 effluxes, and furthermore, these increases cannot be attributed to diffusion processes. We show that displacement plays a consistent role in both agricultural and shrubland sites during various types of pulsed moisture events, highlighting the importance of transport processes such as displacement in understanding the timing of CO_2 release from these soils.

PREVIEW

Table of Contents

PREVIEW

List of Figures

PREVIEW

Introduction

Dryland ecosystems are critical to the global carbon cycle, playing a vital role in the storage and release of carbon (Poulter et al., 2015). These ecosystems are characterized by a unique dryland critical zone, which includes the zone of the Earth's surface that extends from the top of vegetation canopy to the bottom of the groundwater table (Scott & Biederman, 2018). Drylands, which cover about 40% of the Earth's surface (Guo et al., 2016; Roxburgh & Noble, 2001), rely on both inorganic and organic soil carbon as important carbon pools. In particular, dryland soils are known for their unique ability to store large amounts of soil inorganic carbon (SIC), making them key players in the carbon cycle (Gao et al., 2017). One fundamental part of the dryland carbon cycle is soil CO_2 efflux, or the release of carbon dioxide from the soil to the atmosphere (Maier et al., 2011). This process can be a major source of uncertainty in predicting the carbon dynamics of these ecosystems, as it depends on belowground processes that are less well studied and can be influenced by a wide range of factors, including temperature, soil moisture, and land use change (Kumar et al., 2020; Chamizo et al., 2022). Understanding the mechanisms controlling carbon storage and respiration in drylands is therefore essential for accurately estimating carbon budgets and assessing the impacts of environmental changes. By identifying the key drivers of soil CO_2 efflux and other components of the dryland carbon cycle, we can develop more accurate models of carbon storage and release in these systems. This, in turn, can help us develop more effective strategies for mitigating carbon emissions and managing global carbon budgets.

Unlike mesic environments, dryland systems experience infrequent and variable precipitation events followed by chronic shortages of soil moisture (Collins et al., 2014). This causes drylands to go through only short periods of water sufficiency (Knapp et al., 2008). As a

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